INTEGRATED FORECASTING AND RESERVOIR MANAGEMENT
AN ADAPTATION STRATEGY AND A DEMONSTRATION PROJECT

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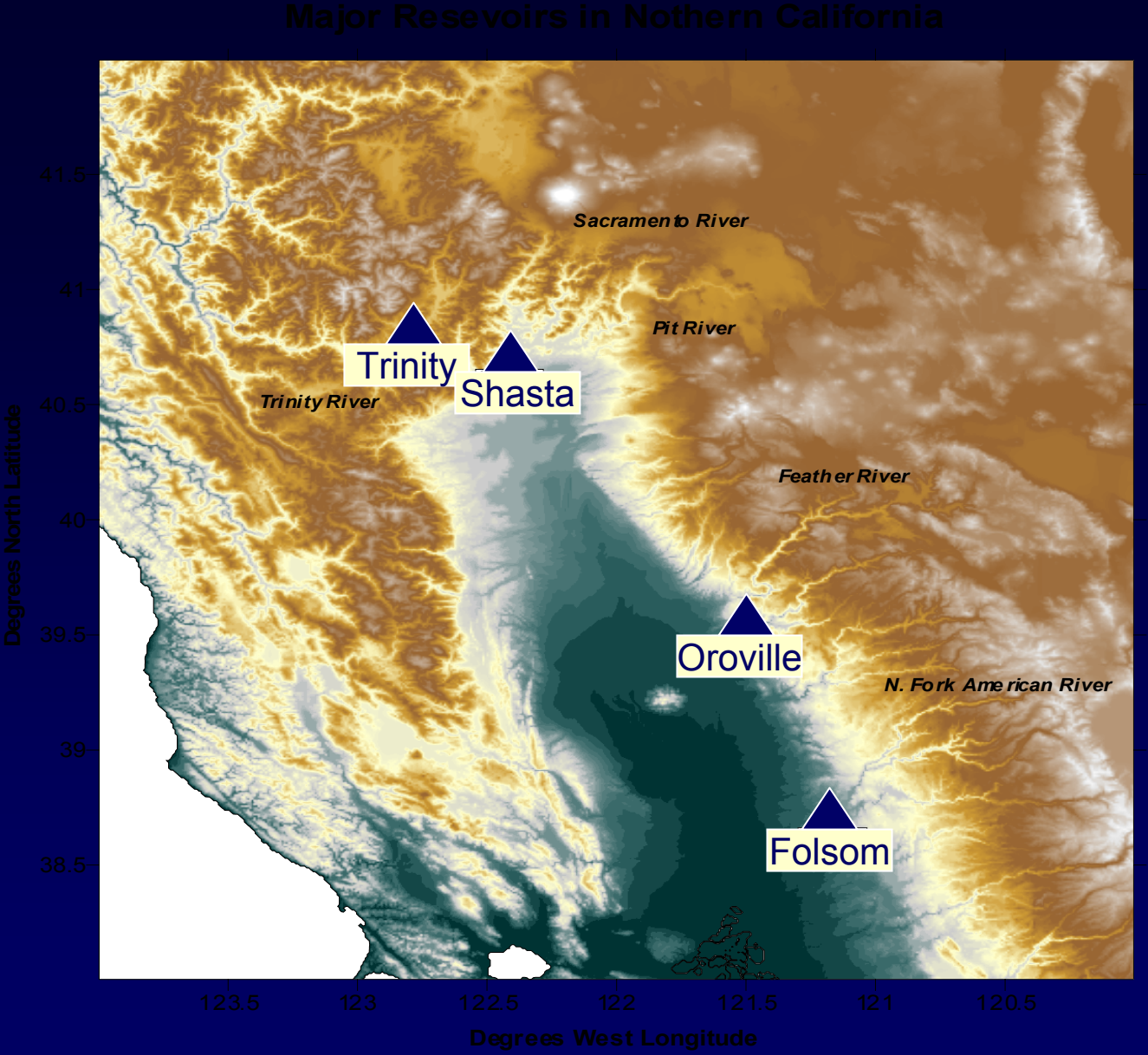
Vision Statement

- Increase efficiency of water use in Northern California using climate, hydrologic and decision science

Goal and Objectives

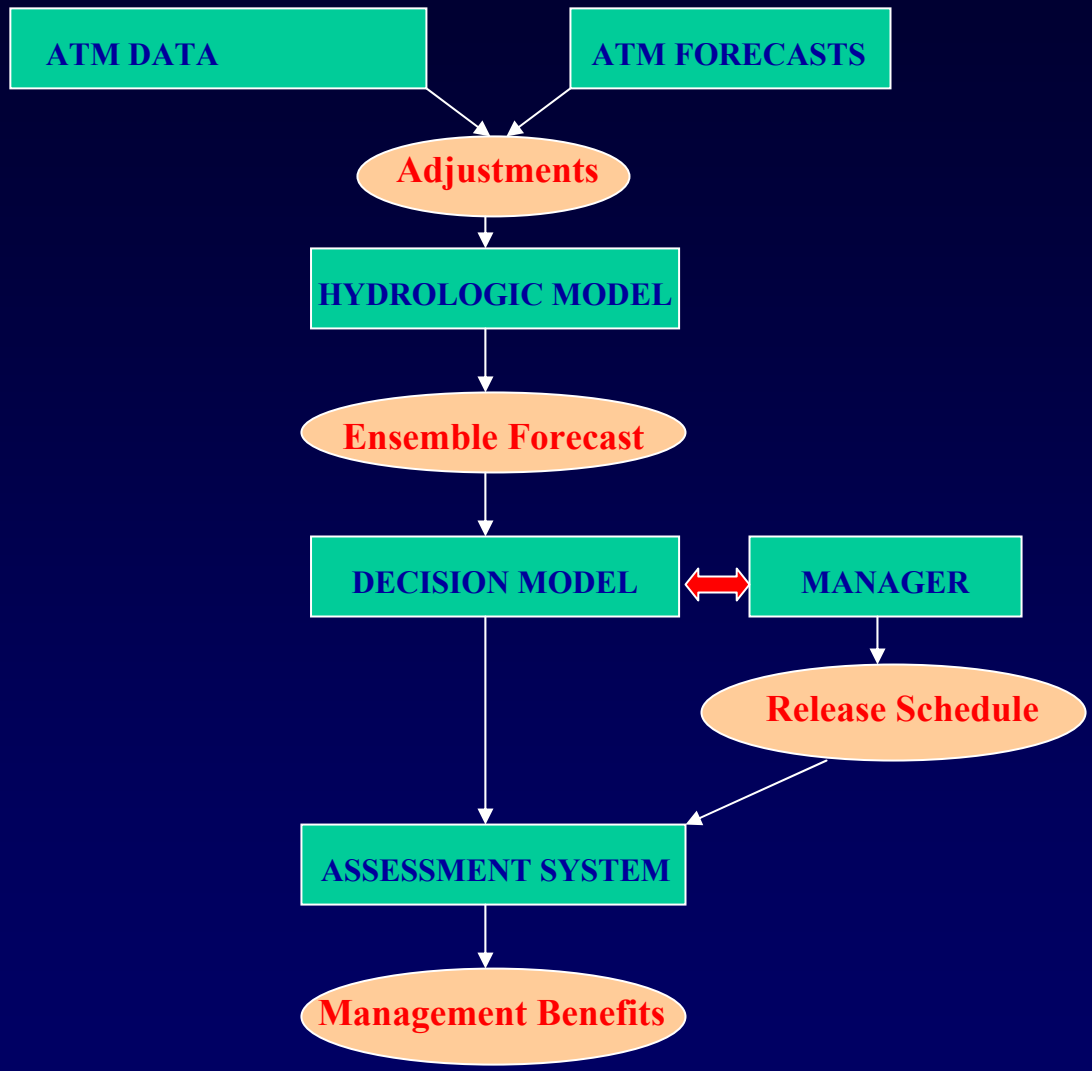
- Demonstrate the utility of climate and hydrologic forecasts for water resources management in Northern California
- Implement integrated forecast-management systems for the Northern California reservoirs
- Perform tests with actual data and with management input

Application Area



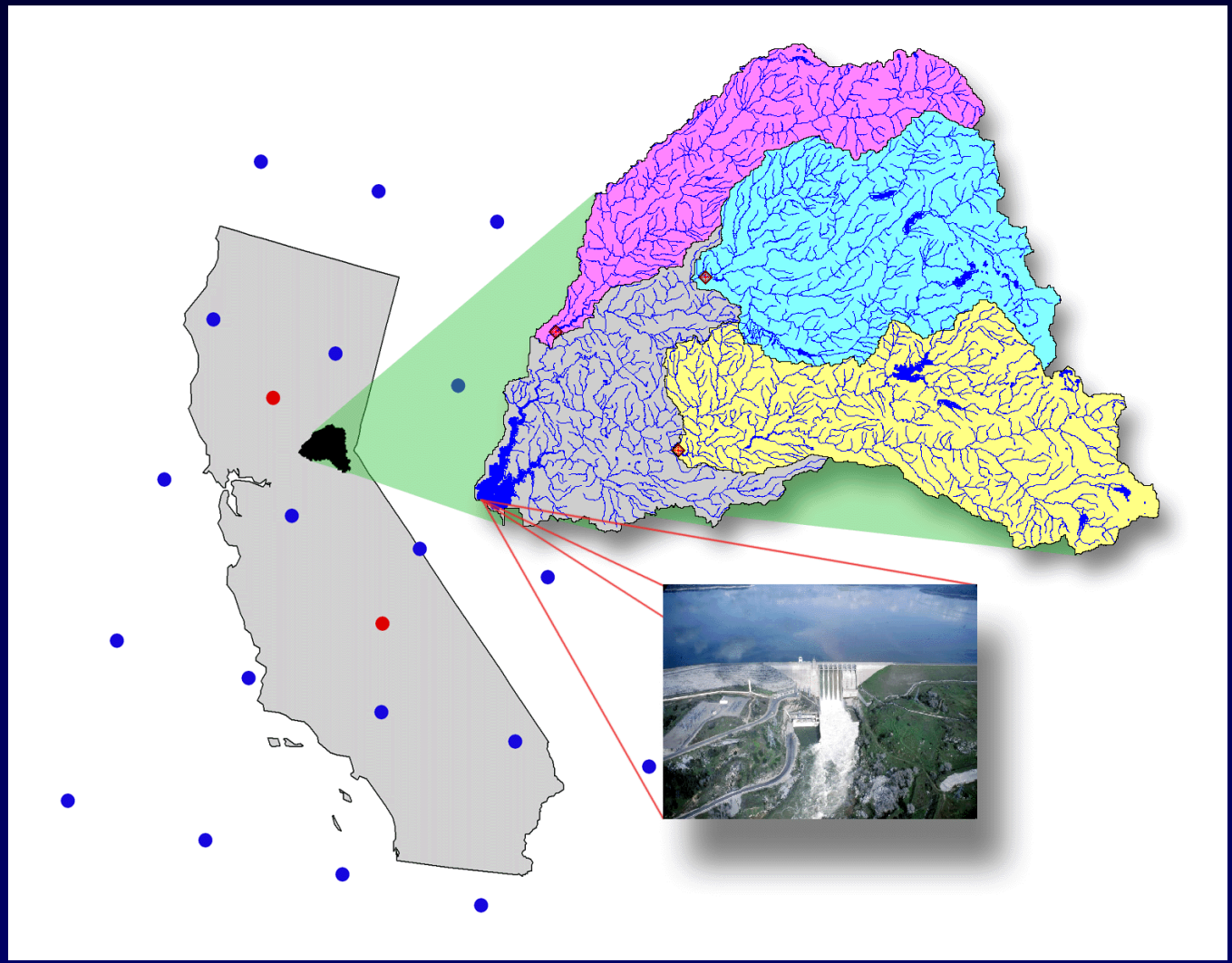
PRINCIPAL INVESTIGATORS

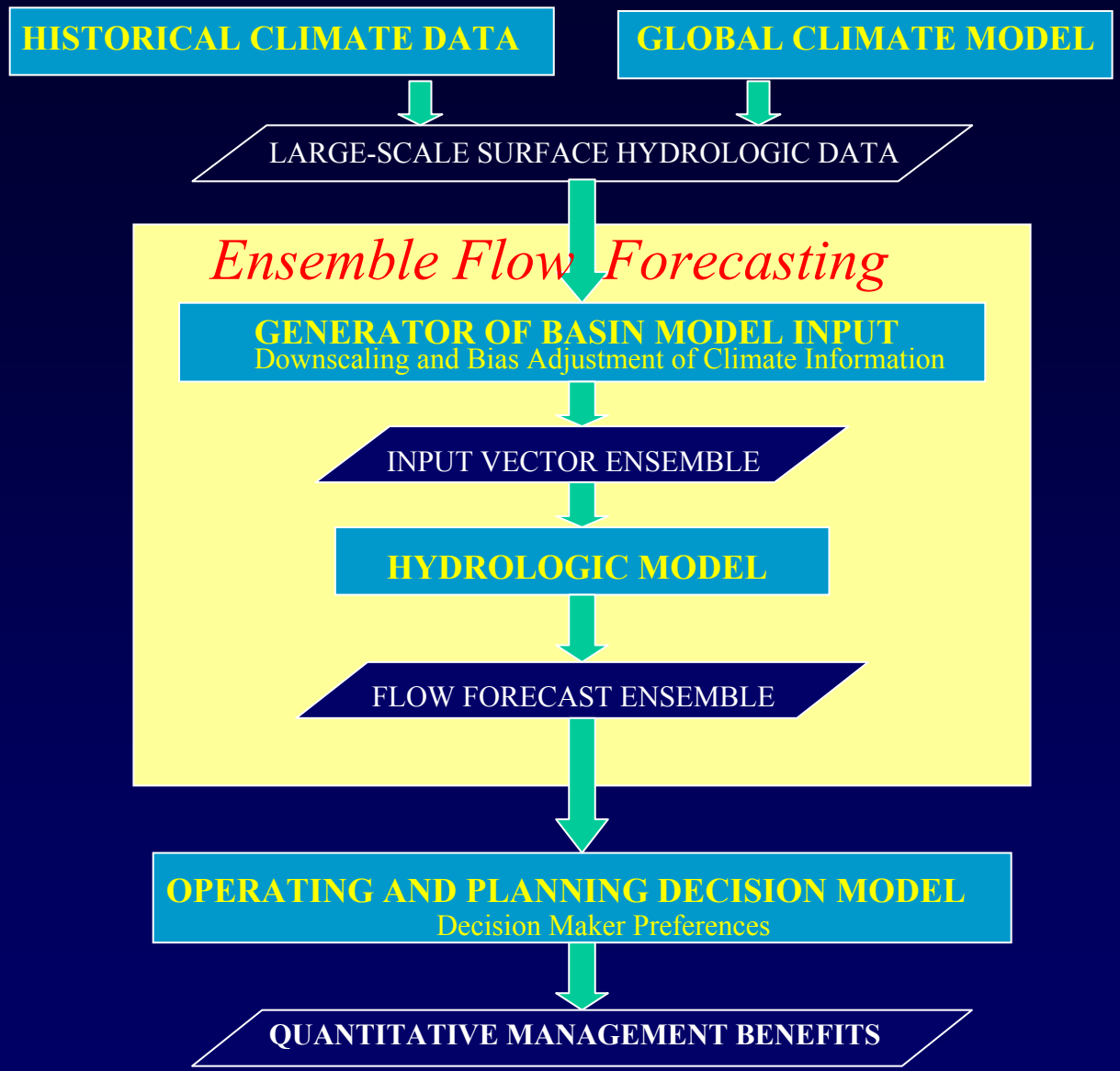
- HYDROLOGIC RESEARCH CENTER
  - Kosta Georgakakos – Hydrology
  - Nick Graham – Climate
- GEORGIA WATER RESOURCES INSTITUTE
  - Aris Georgakakos – Reservoir Management



Integrated System Diagram

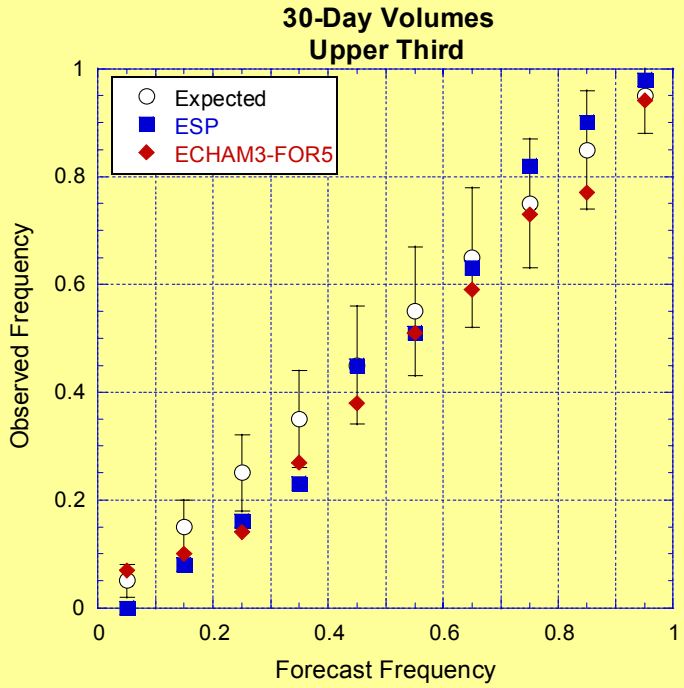
Feasibility Studies for Folsom System

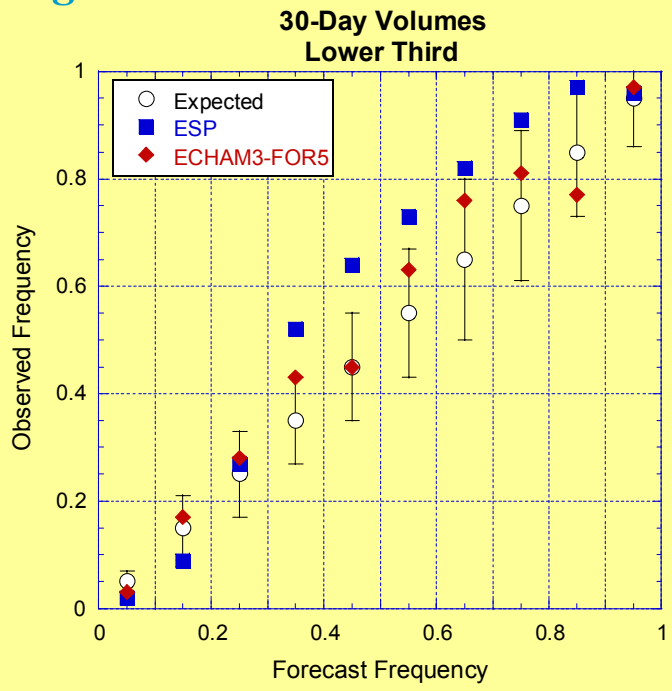


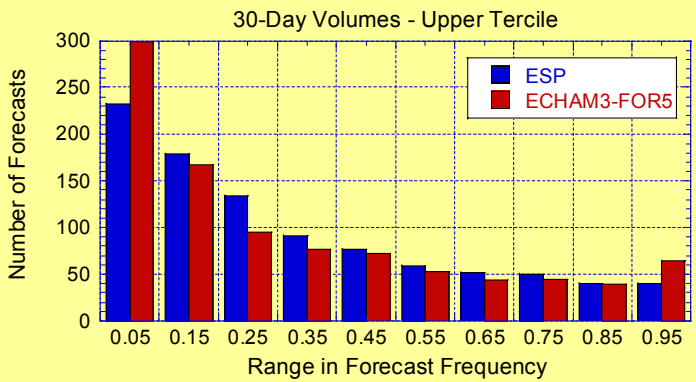

HISTORICAL CLIMATE DATA
GLOBAL CLIMATE MODEL
LARGE-SCALE SURFACE HYDROLOGIC DATA
Ensemble Flow Forecasting
GENERATOR OF BASIN MODEL INPUT
Downscaling and Bias Adjustment of Climate Information
INPUT VECTOR ENSEMBLE
HYDROLOGIC MODEL
FLOW FORECAST ENSEMBLE
OPERATING AND PLANNING DECISION MODEL
Decision Maker Preferences
QUANTITATIVE MANAGEMENT BENEFITS

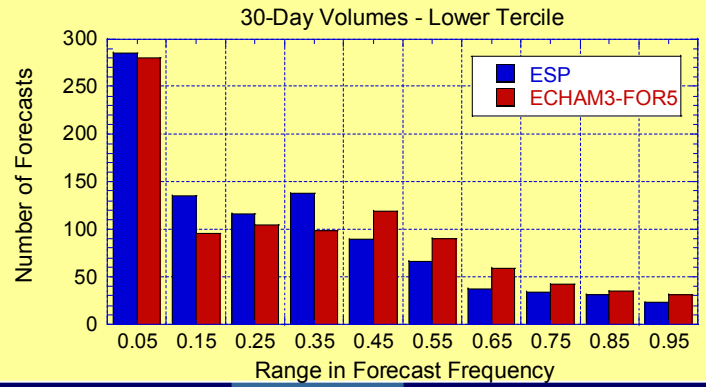
FOLSOM ENSEMBLE FORECASTS 1970-1993 (OCT-APR)

Reliability Diagrams

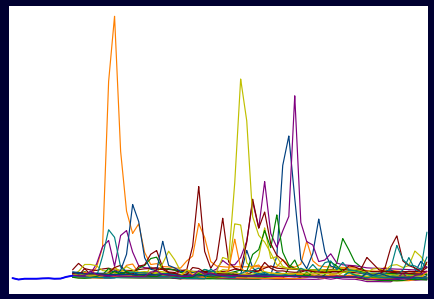








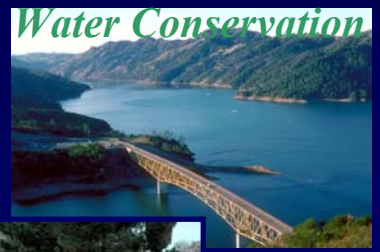
MANAGEMENT

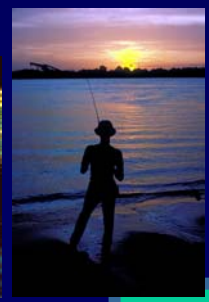


Decision Models

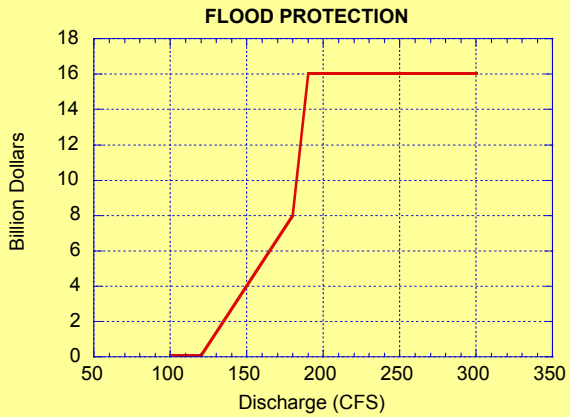
Long Term (weekly)	Short/Mid Term (hourly)	Turbine Load Dispatching
ELQG	DP	DP
Long Range Tradeoffs Seasonal Water Management	Hourly Release Power Sequences	Turbine Loads Spillway Outflows

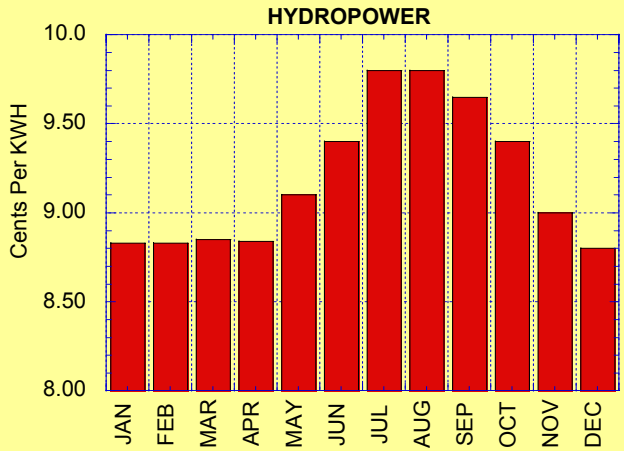
Management Benefits

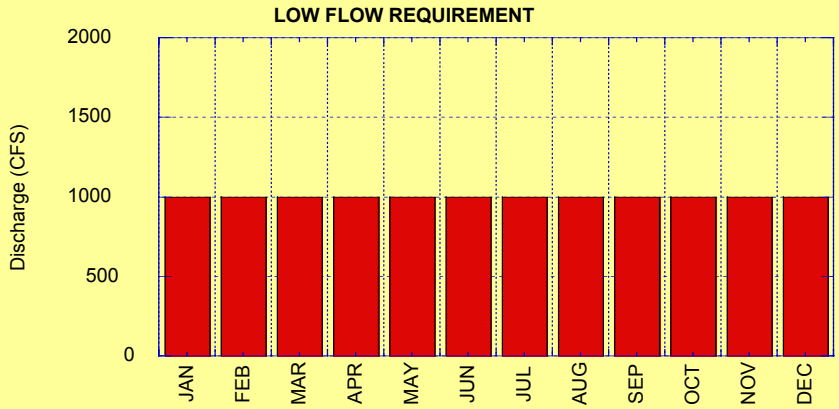




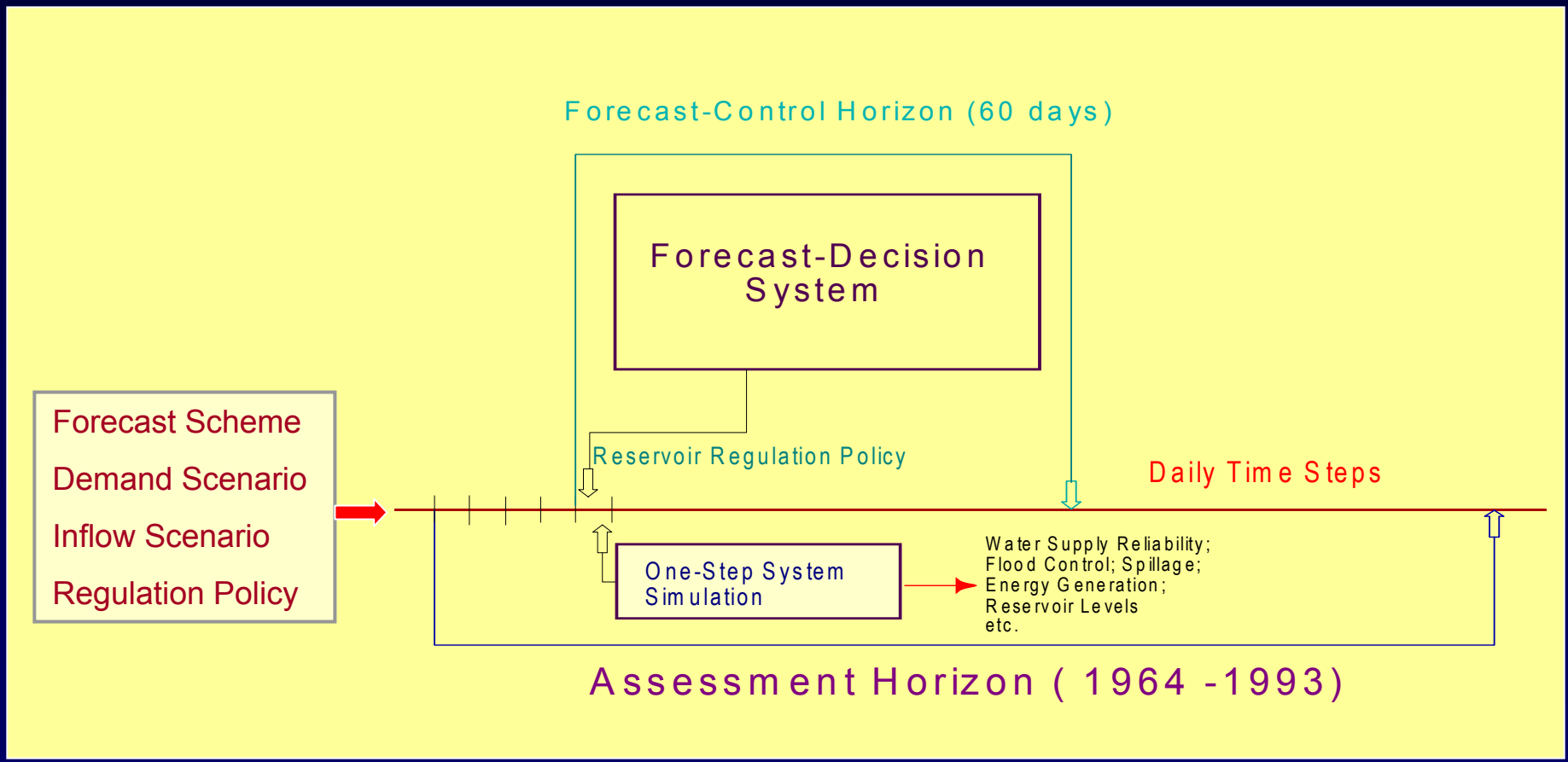
FOLSOM LAKE MANAGEMENT OBJECTIVES







Assessment Component



Assessment Run (Heuristic vs. Dynamic Decision Rules)

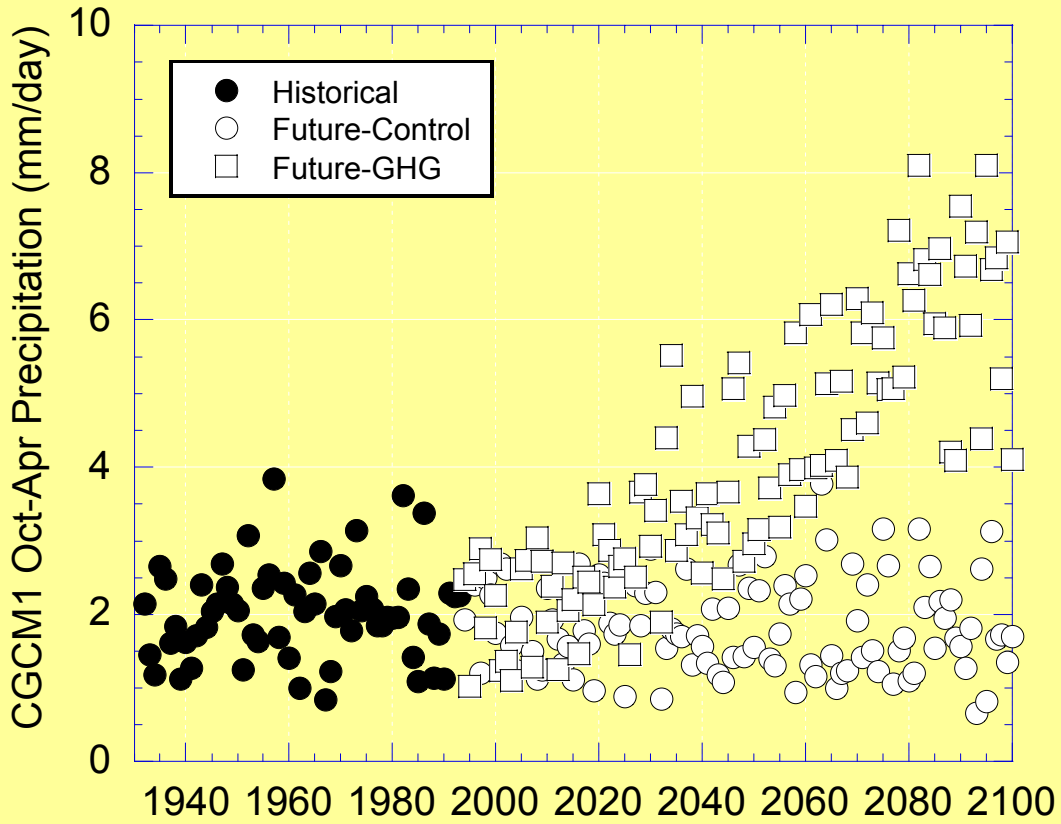
Historical Climate Assessments Using the **Heuristic Decision Rule**

Forecast Scheme	Upstream Storage (1000 Ac-Ft)	Energy (GWH)	Energy Value (Million $)	Spillage (BCF)	Min. Flow Violations (Days)	Flood Damage (Million $)
Operational Forecasts	200	583.9	53.23	12.99	0	0
Ensemble Forecasts	200	583.7	53.20	13.00	0	0
Perfect Forecasts	200	584.4	53.30	12.94	0	0

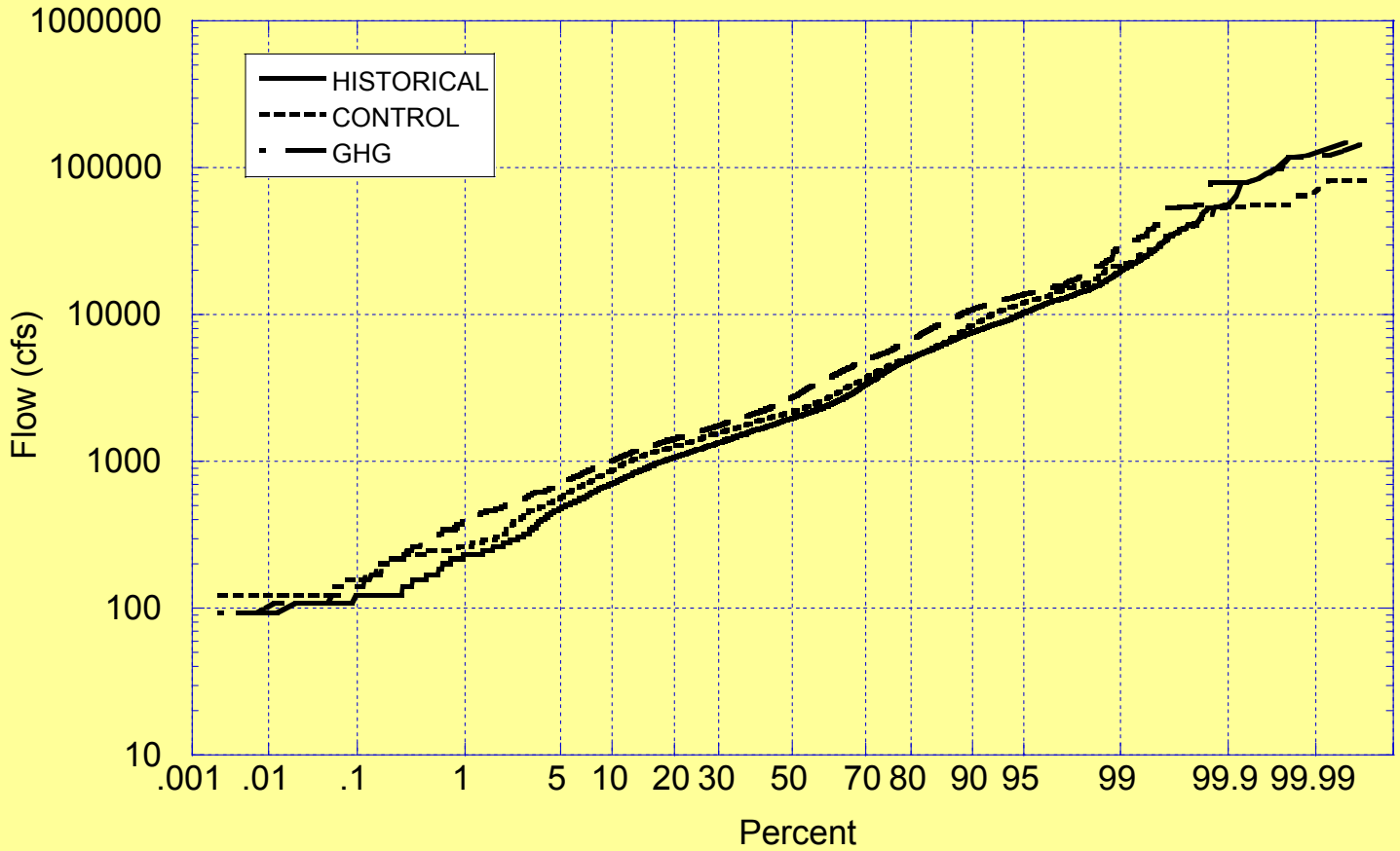
Historical Climate Assessments Using the **Folsom DSS**

Forecast Scheme	Reliability	Energy (GWH)	Energy Value (Million $)	Spillage (BCF)	Min. Flow Violations (Days)	Flood Damage (Million $)
Operational Forecasts	Deterministic	620.06	56.37	11.57	0.00	841.48
Ensemble ESP	50%	615.55	56.02	12.58	0.00	841.48
	90%	637.11	57.80	5.98	0.00	0.00
Perfect Forecasts	Deterministic	662.41	60.22	4.84	0.00	0.00

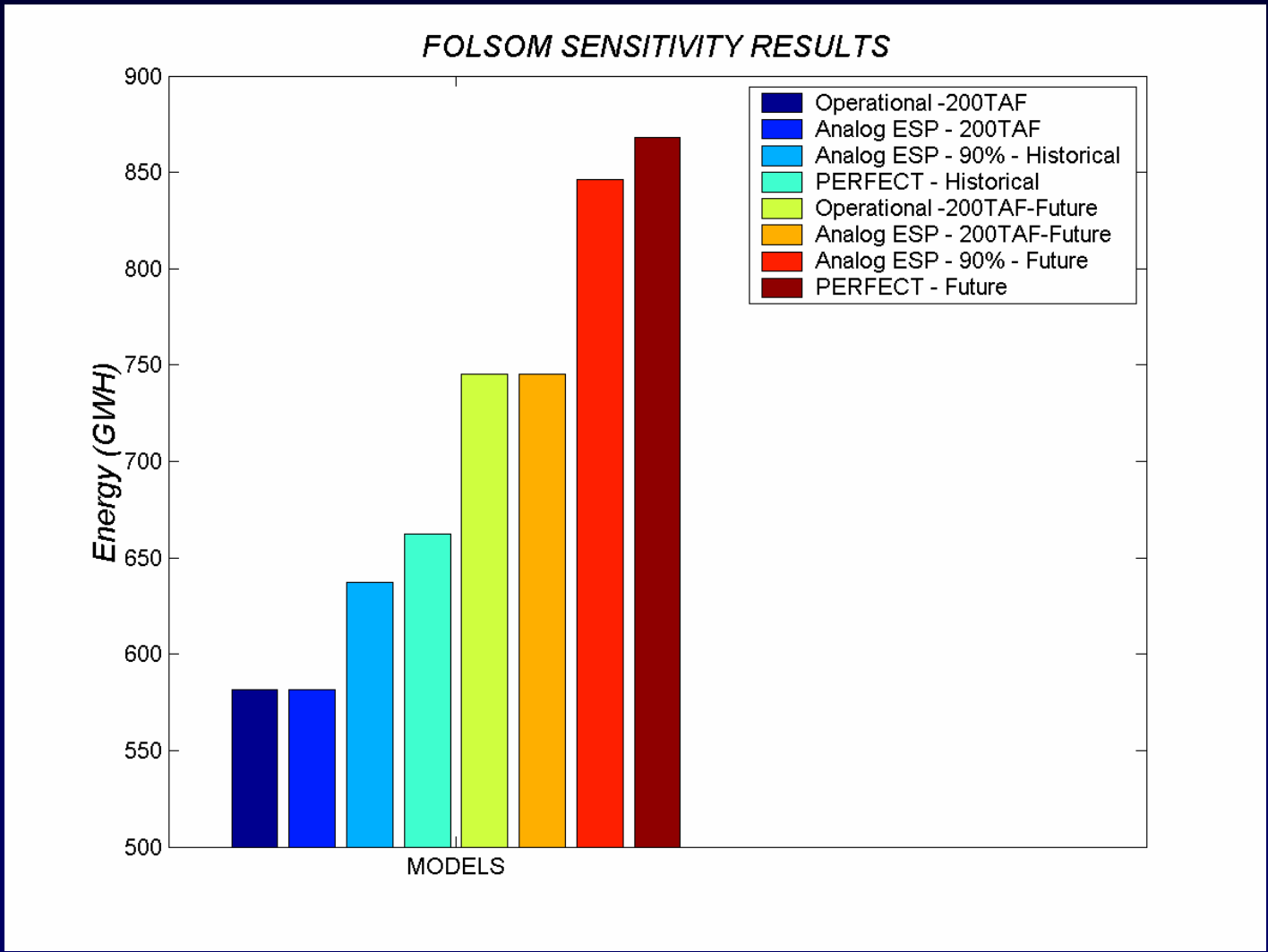
Climate Change GCM-Conditioned Historical Scenario - MAP



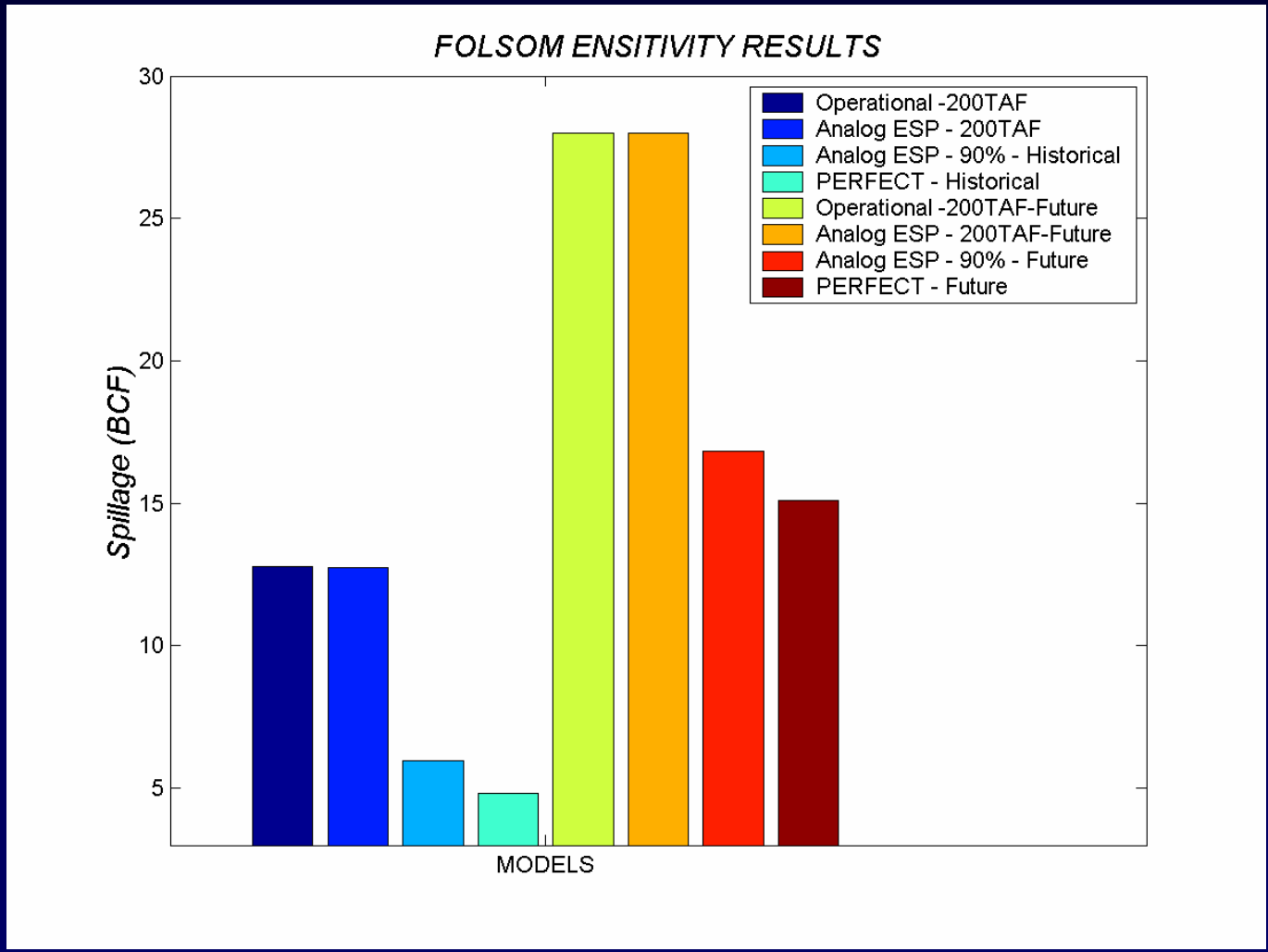
Climate Change GCM-Conditioned Historical Scenario - Flows



Climate Change GCM-Conditioned Historical Scenario - Energy



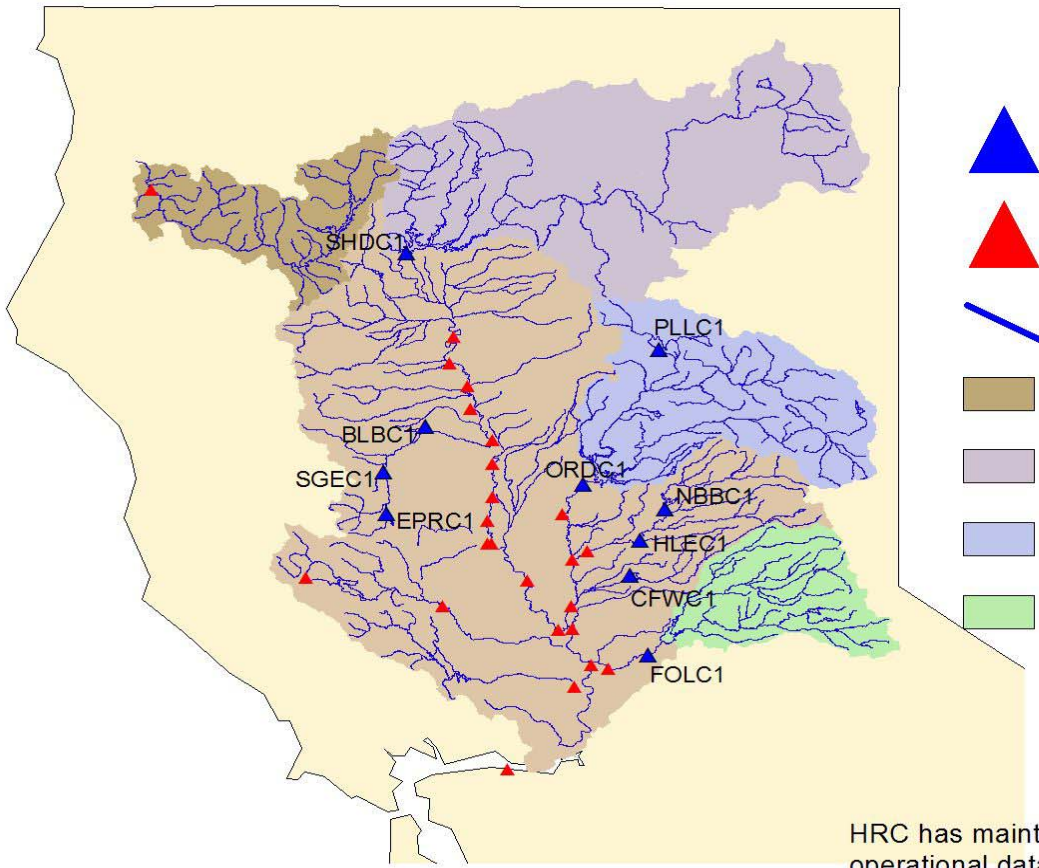
Climate Change GCM-Conditioned Historical Scenario - Spillage



Conclusions from Feasibility Study

- Management policy significant for allowing the realization of the economic value of reliable ensemble forecasts for reservoir management
- Uncertainty modeling significant when using climate and hydrologic forecasts for reservoir management
- Improvements to current reservoir management appear feasible with appropriate integrated forecast management systems
- Demonstration project is a logical next step for evaluating actual system benefits

Inform Catchment



Reservoir Inflow

Forecast locations

streams

Trinity R basin

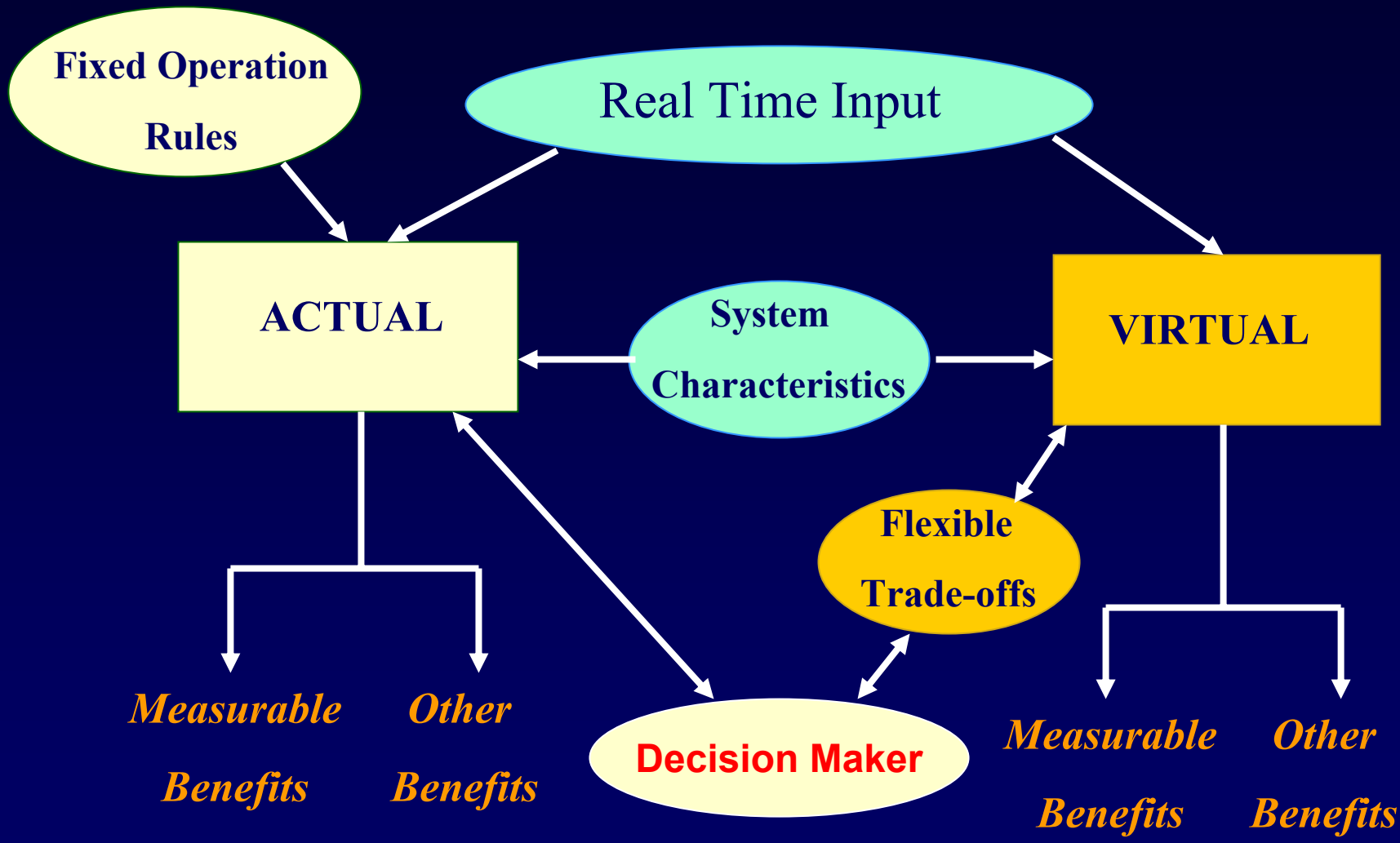
Shasta Dam basin

Oroville Dam basin

Folsom Dam basin

HRC has maintained an archive of CNRFC operational database from1998-current

INFORM Demonstration Concept



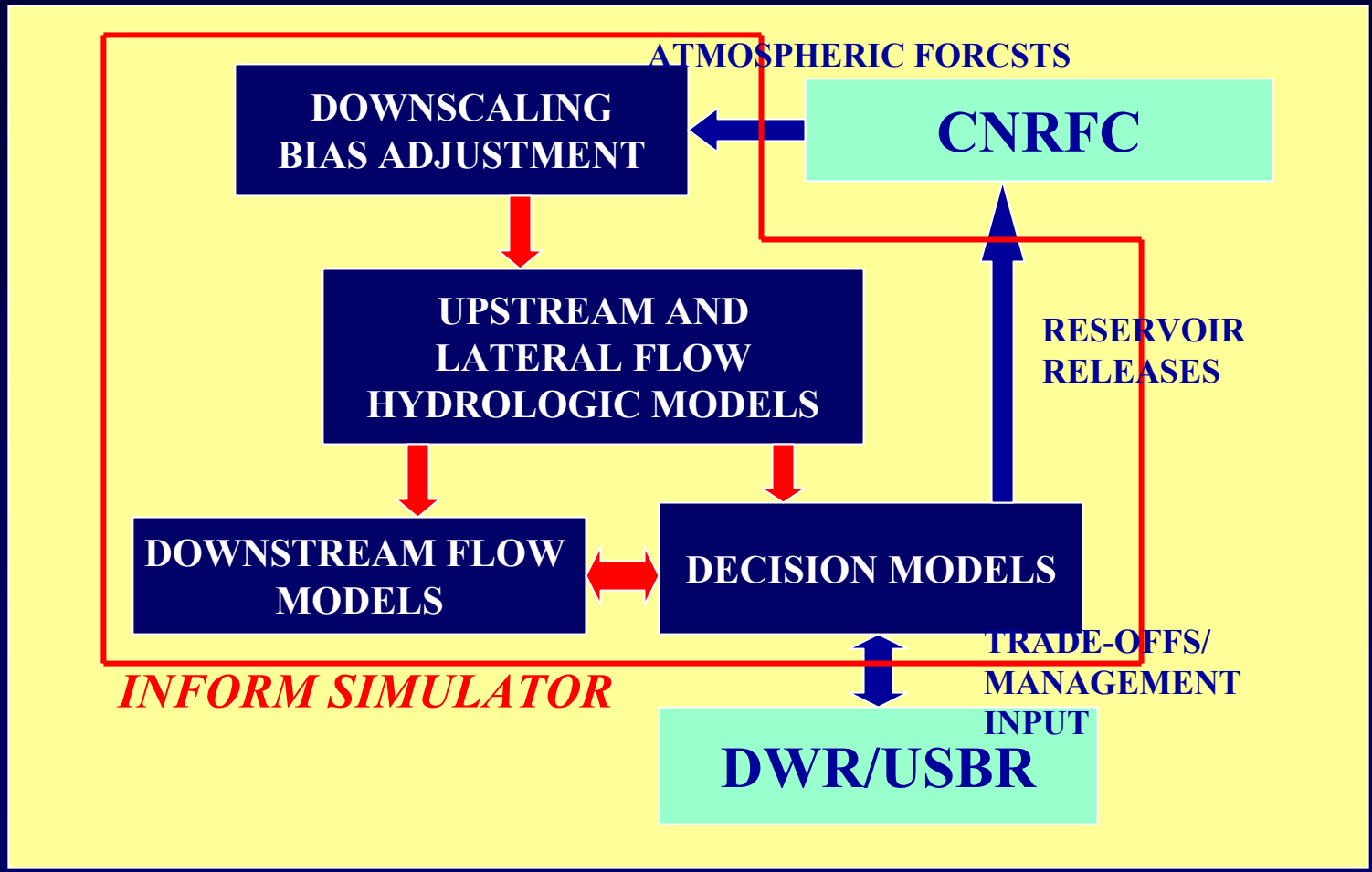
Implementation Strategy

- Link climate and weather forecasts of precipitation and temperature to hydrologic models
- Link decision models with forecasts and downstream objectives to assess alternative policy options
- Run integrated forecast-decision system for selected cases with management input to assess performance
- Order of implementation: from individual reservoirs to the multi-reservoir system
- Collaborative Workshops

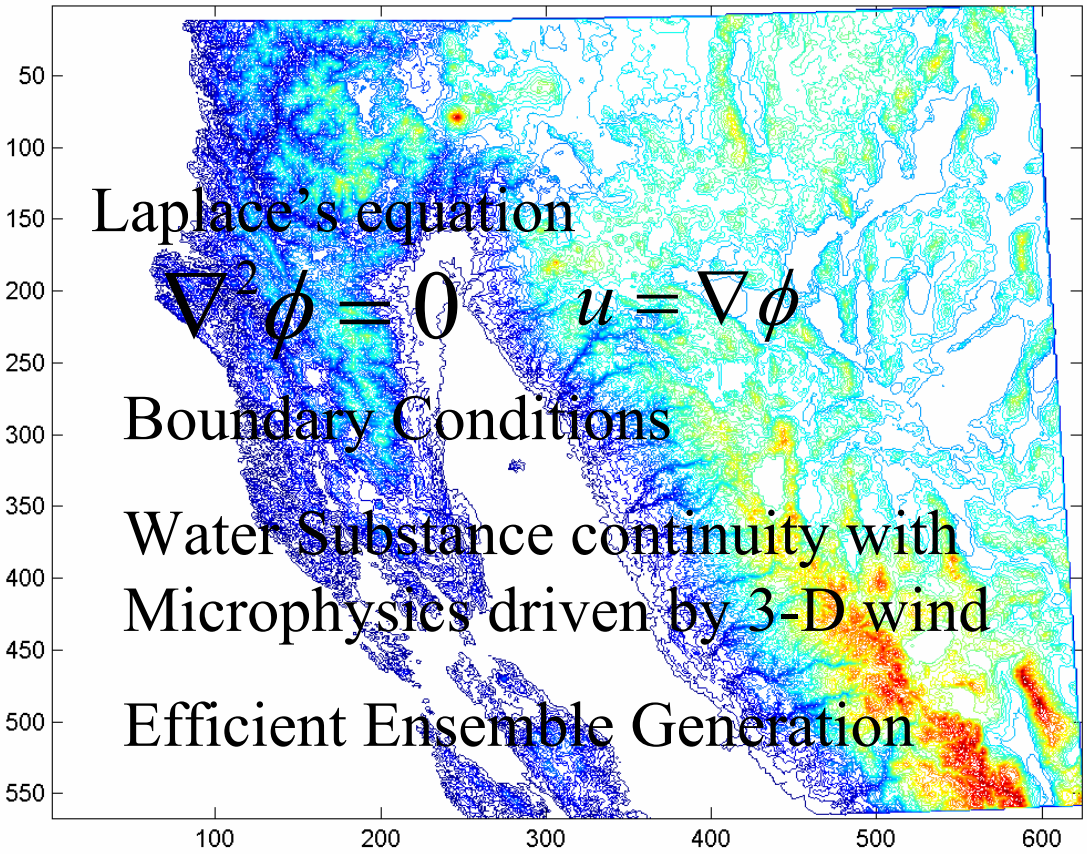
Work Accomplished

- Coordination and Initial Design of the Weather and Climate Ingest Component
- Design, Implementation and Validation of Precipitation Downscaling Component
- Validation of Operational CNRFC Snow and Hydrology Models for American and Feather Rivers
- Design and Implementation of Stand Alone Ensemble Flow Forecast System for Folsom and (in progress) for Oroville
- Design and Implementation of Decision Support System for Folsom and Oroville Reservoirs

Software/platform/database and links to operations



Simplified Orographic Surface Precipitation Model



Laplace's equation

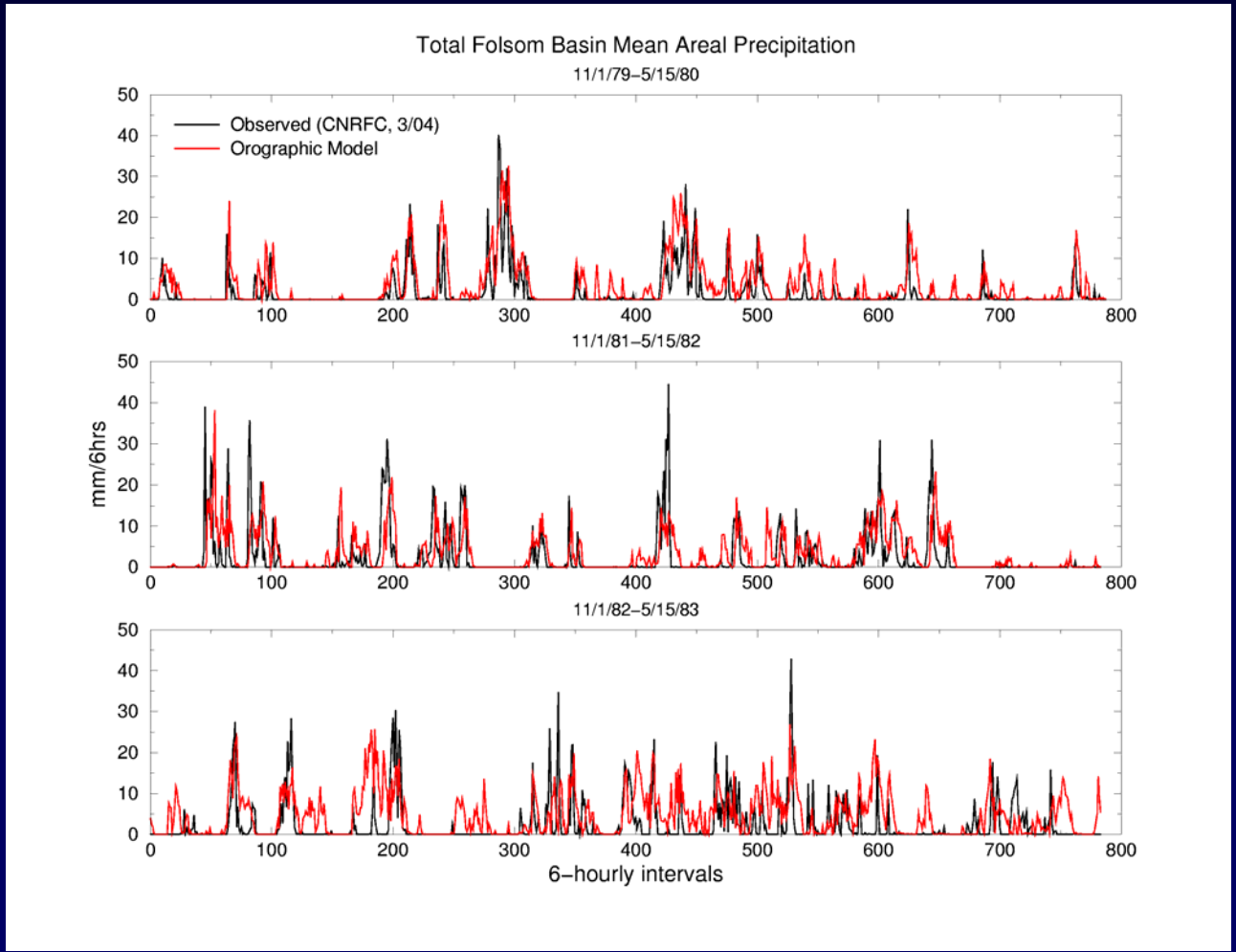
$$\nabla^2\phi = 0 \qquad u = \nabla\phi$$

Boundary Conditions

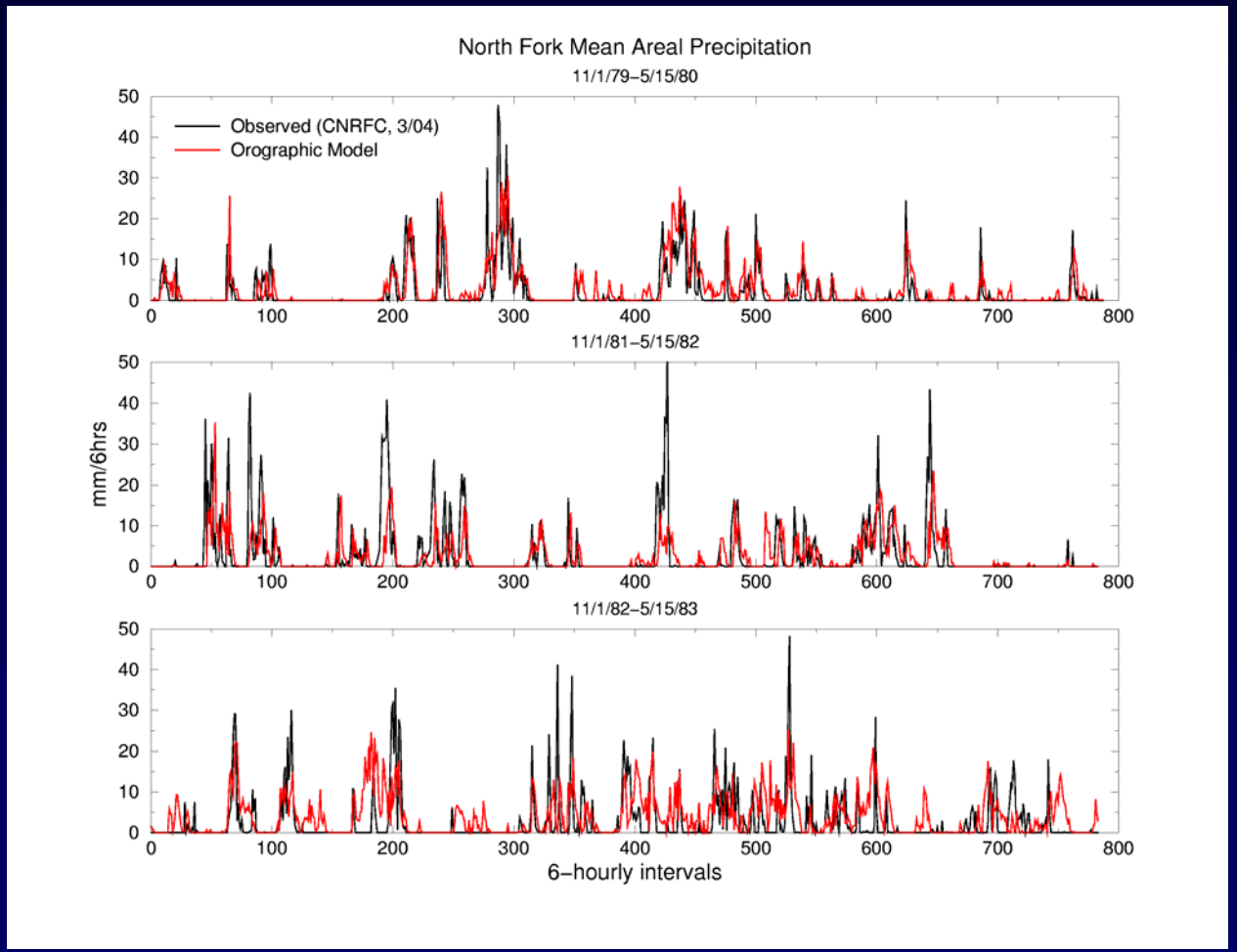
Water Substance continuity with Microphysics driven by 3-D wind

Efficient Ensemble Generation

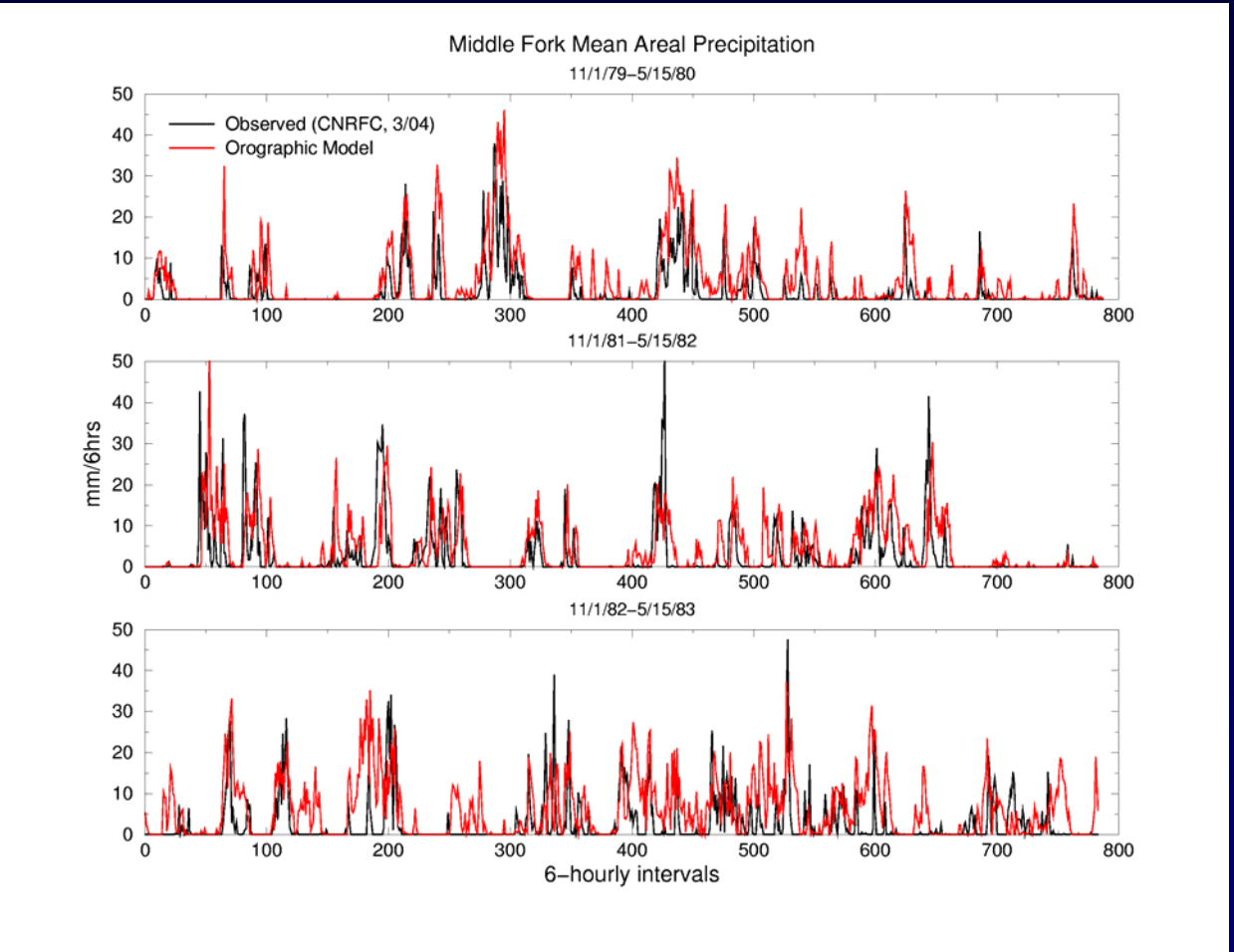
Downscaling Precipitation



Downscaling Precipitation



Downscaling Precipitation



Downscaling Precipitation

Wet Season (1969-1992)

	Folsom Lake	*North Fork*	*Middle Fork*	*South Fork*
Six-Hourly Data				
ρ	0.52	0.49	0.48	0.46
m/μ	-0.46	-0.02	-0.74	-1.00
Daily Accumulations				
ρ	0.67	0.66	0.65	0.64
m/μ	-0.66	-0.11	-0.97	-1.30

Team Members

- Theresa Carpenter, Hydrologic Modeling
- Eylon Shamir, Hydrologic Modeling and Parameter Estimation
- Jason Sperfslage, Computer Systems Programmer
- Steve Taylor, Downscaling and Statistical Validation
- Jianzhong Wang, Numerical Mesoscale Modelling
- Huaming Yao, Decision Support System Development

Funding Agencies

- CEC – PIER
- California Bay Delta Authority
- National Oceanic and Atmospheric Administration
- USA Corps of Engineers

INFORM COLLABORATIONS